WAVELET ANALYSIS OF AIR-SEA INTERACTION

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LONG-TERM GOAL

My long term goal is to study nonlinear air-sea interaction processes by using wavelet transform. Of particular interest to me are the development of one- and two-dimensional wavelet analysis of field and satellite data for air-sea interaction, such as oceanic fronts, and internal waves.

SCIENTIFIC OBJECTIVES

I wish to investigate the influence of waves on wind stress vector, momentum flux, and heat flux in the marine boundary layer and develop the method for wavelet analysis of air-sea interaction.

APPROACH

The wavelet transform gives a new description of spectral decompositions via the scale concept. It selectively matches, by means of a scalar product, transient features characterized by unknown locations and time extent. It is this property that makes it relevant for many nonstationary signal processing tasks, and especially for time-varying analysis. Wind and wave observations from a ship in the Surface Wave Dynamics Experiment (SWADE) were analyzed using wavelet decomposition of the time series to study wind-wave interaction (Liu et al, 1995; Peng et al., 1995; Chapron, et al., 1995). The two-dimensional wavelet transform is a very efficient bandpass filter, which can be used to separate various scales of processes and show their relative phase/location. In this project, algorithms and techniques for detection and tracking of mesoscale oceanic features from satellite imagery employing wavelet analysis are developed.

WORK COMPLETED

With the wavelet analysis we can detect wave groups and intermittent events in the wave signal from SWADE. We have analyzed the geometric characteristic of the envelopes of wave packets using 1D wavelet transform. The forward face and rear face asymmetry ratio of the wave packets were examined. The 2D wavelet transform has been applied to satellite images, such as those from Synthetic Aperture Radar (SAR) for feature extraction (Liu et al., 1997). Also, the internal wave packets with more than 15 solitons were observed and measured by the ERS-1 SAR and the thermistor chain from a research ship

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in the Yellow Sea. Based on the SAR images, these many solitons may be caused by the internal wave-wave interaction.

RESULTS

For swell groups, the momentum flux is upward from waves to wind. The wind stress vector generally lies between the mean wind direction and the direction of the swell. We also found that the histograms of the amplitude of the wave packet envelope are distorted from a Rayleigh distribution and are quiet different between wave-against-wind case and wave-along-wind case. In the former case the envelope peak shifts towards larger amplitude, while the later case shifts towards smaller amplitude. We have collected many SAR images in the Yellow Sea to help the field test planning in the Yellow Sea in August 1996. Based on the observations of SAR images, the interaction of nonlinear internal wave packets in the Yellow Sea results in the merge of solitons to a single larger internal wave packet.

IMPACT/APPLICATION

The evolution of mesoscale features such as oil slicks, fronts, eddies, and internal waves can be tracked by the wavelet analysis using satellite data from repeating paths. The effects of internal wave on acoustic propagation is a very important issue as demonstrated in the Yellow Sea Acoustic/ Internal Wave Experiment carried out in August, 1996.

TRANSITIONS

Our one-dimensional Morlet wavelet transform code has been distributed to many agencies and academic institutes. We have been acknowledged by authors in many papers applied our wavelet techniques in various journals. I received a peer award at NASA/GSFC for this outstanding achievement in FY95. We have developed this two-dimensional wavelet transform technique for NASA SAR project, NOAA coastal watch and fisheries-oceanography coordinated investigations (FOCI), and can be also useful for ONR Remote Sensing Program.

RELATED PROJECTS

Dr. John Apel and I work together on the effects of internal wave on acoustic propagation in the Yellow Sea Acoustic/Internal Wave Experiment carried out in August, 1996. The in-situ stratification, and current measurements from Dr. Ji-Xuan Zhou of George Inst. Tech. will provide a validation on our SAR observations and an input for the numerical simulations of wave evolution in the Yellow Sea.

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